# METHODS OF SAMPLING AND TESTING
# MT 202-04
# SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE
# MAXIMUM SIZE THROUGH 200 MESH
## *(Modified AASHTO T 11 and T 27)*

**1 Scope:**

**1.1** This method covers the determination of the particle size distribution of fine and coarse aggregates by sieving.

**1.2** Material Passing the 4.75 mm (no. 4) sieve will be washed. Clay particles and other aggregate particles that are dispersed by the wash water, as well as water-soluble materials, will be removed from the aggregate during testing.

**2 Referenced Documents:**

**2.1** ***AASHTO:***

T11 Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
T27 Sieve Analysis of Fine and Coarse Aggregates

***MT Manual:***

MT-201 Sampling Roadway Materials
MT-405 Wire Cloth Sieves for Testing Purposes
MT-417 Reducing Field Samples to Testing Size

**3 Apparatus:**

**3.1** *Balance* - The scale or balance for the coarse material (plus 4 mesh) shall have a sensitivity of 0.01 pounds or 0.01 kilograms. Coarse material weights shall be recorded to the nearest 0.01 of a pound or 0/.01 kilogram. The scale or balance for the fine material (minus 4 mesh) shall have a sensitivity of 0.1 gram. Fine material weights shall be recorded to the nearest 0.1 gram.

**3.2** *Sieves* - The sieves with square openings shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The sieves shall conform to the requirements of MT-405, Wire Cloth Sieves for Testing Purposes.

**3.2.1** *Sieves*--A nest of two sieves, the lower being a 75-*µ*m (No. 200) sieve and the upper being a sieve with openings in the range of 2.36 mm (No. 8) to 1.18 mm (No. 16), both conforming to the requirement of MT 405.

**3.3** *Container* - A container sufficient to contain the sample covered with water and to permit vigorous agitation without inadvertent loss of any part of the sample or water is required. The container shall be approved by the District Materials Supervisor or Area Laboratory Supervisor prior to use.

**3.4** *Oven* - An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F) is required.

**4 Preparation of Samples:**

**4.1** Samples for sieve analysis shall be prepared in accordance with MT-417, Reducing Field Samples to Testing Size. The samples shall be the weight desired when dry. The selection of samples of an exact predetermined weight shall not be attempted.

**4.2** Dry the sample at a temperature of 110 ± 5°C (230 ± 9°F) to a constant weight. For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate for the sieve analysis test. The results are insignificantly affected by the moisture

**4 Preparation of Samples:** (continued)

content unless the nominal maximum size is smaller than 12.5 mm (½ in.), or the coarse aggregate contains appreciable material finer than 4.75 mm (No. 4); or the coarse aggregate is highly absorptive (a lightweight aggregate, for example). Samples may be dried at higher temperatures associated with the use of hot plates without affecting results, provided steam escapes without generating pressures sufficient to fracture the particles, and temperatures are not so great as to cause chemical breakdown of the aggregate.

*NOTE 1 - Samples taken for Liquid Limit, Plastic Limit, and Plasticity index shall be air dried or dried at a temperature no greater than 140°F or 60°C.*

**4.3** Samples are considered dry when complete separation of the coarse aggregate from the minus 4 mesh material is observed, and the material is dryer than SSD (Saturated Surface Dry). **NOTE: Two moisture checks per shift will be required.**

**4.4** Representative samples will be graded to determine the percentage of fine material adhering to the coarser fractions. At least one sample shall be taken by field personnel at the start of production of aggregate. When material is being removed from the stockpile before production of aggregate has concluded, it is suggested that more samples be taken to insure uniform production. The District Materials Supervisor or Area Laboratory Supervisor will determine the total number and weight of samples graded. The Materials Bureau will require one sample from the material submitted for mix design.

**4.5** *Fine Aggregate* - The test sample of fine aggregate shall weigh, after drying, approximately the following amount:

Aggregate with at least 95% passing a 2.36 mm (No. 8) sieve . . . 100g
Aggregate with at least 85% passing a 4.75 mm (No. 4) sieve
and more than 5% retained on a 2.36 mm (No. 8) sieve . . . . . 500g

**4.6** *Coarse Aggregate* - The weight of the test sample of coarse aggregate shall conform with the following minimum weights:

| SPECIFIED 100% PASSING SIEVE SIZE | | Min. Field Test Sample Size* | |
|---|---|---|---|
| mm | In | Kg | lbs. |
| *9.5 | (3/8) | 6.8 | 15 |
| *12.5 | (1/2) | 6.8 | 15 |
| *19.0 | (3/4) | 9.1 | 20 |
| *25.0 | (1) | 11.3 | 25 |
| *37.5 | (1 ½) | 15 | 33 |
| 50 | (2) | 20 | 44 |
| 63 | (2 ½) | 35 | 77 |

*NOTE 2* - For cover material, concrete aggregate, and samples that require a wear, cleanliness value test, the sample size sent to Helena must be doubled.

**4.7** *Coarse and Fine Aggregate Mixtures* - The weight of the test sample of coarse and fine aggregate mixtures shall be the same as for coarse aggregate.

## 5 Procedure for Clinging Fines:

**5.1** Follow the procedure in Section 4 for the original test. Save the plus 4.75 mm (4 mesh) material.

**5.2** Wash the plus 4.75 mm (4 mesh) material over a protected 75 μm (200 mesh) screen. In most cases it is not necessary to rewash the minus 4.75 mm (4 mesh) material. Dry and re-screen over the original sized screens. Use the original weight of sample taken for the calculation of the plus 4.75 mm (4 mesh) percentages.

**5.3** Obtain the difference between the original plus 4.75 mm (4 mesh) material and the washed plus 4.75 mm (4) material. Record for use in calculations of the minus 4.75 mm (4 mesh) material. To convert from the pounds of minus 4 mesh material to grams, multiply by 453.6.

Example: (0.39 pounds) X (453.6) = 176.9 grams.

Use the percentage difference passing the 4.75 mm (4 mesh) divided by the before wash weight to get the reciprocal for multiplication.

Example: (1.55%)/176.9 g) = 0.0088

**5.4** The total percent clinging fines is the difference in percent of the plus 4.75 mm (4 mesh) screen sizes.

Example: 55.61(dry) - 54.06(washed) = 1.55% (report as 1.6%)

## 6 Procedure for Aggregate Without Clinging Fines:

**6.1** The total sample as prepared in Section 4 shall be separated into a series of sizes. To determine compliance with the specifications for the material under test, avoid overloading the screens.

**6.2** *PLUS 4 MESH PORTION* - The individual weights of the air dried plus 4 mesh portion of the sample, retained on each screen, shall be determined and recorded.

**6.2.1** The individual portions shall be saved until the entire plus 4.75 mm (4 mesh) portion of the sample has been screened, weighed and the weights recorded, before any of the material is discarded.

**6.2.2** The total amount of material finer than the 4.75 mm (4 mesh) sieve may be determined by subtracting the total weight of material retained on the plus 4.75 mm (4 mesh) sieve from the total weight of the sample being tested.

**6.3** *MINUS 4 MESH PORTION* - At the completion of the sieving as described in Section 6.2, the entire minus 4.75 mm (4 mesh) portions shall be thoroughly mixed and reduced to a minimum of 500 grams.

**6.3.1** After drying and weighing, place the test sample in the container and add sufficient water to cover it. A detergent, dispersing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the 75 μm (No. 200) sieve from the coarser particles. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the 75 μm (No. 200) sieve from the coarser particles, and to bring the fine material into suspension. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample.

**6.3.2** Add a second change of water to the sample in the container, agitate, and decant as before. Repeat the operation until the wash water is clear.

**6 Procedure for Aggregate Without Clinging Fines:** (continued)

**6.3.3** Following the washing of the sample and flushing any materials retained on the 75 *µ*m (No. 200) sieve back into the container, no water should be decanted from the container except through the 75 *µm* sieve, to avoid loss of material. Excess water from flushing should be evaporated from the sample in the drying process. The washed aggregate shall be dried to constant mass. Constant mass has been reached when there is less than a 0.1 percent change after an additional 30 minutes of drying for ovens or when close control of temperature is not required, such as hot plates, an additional 20 minutes drying.

*NOTE 3 - A minimum drying time will be established and posted in the test trailer and checked periodically.*

**6.3.4** The individual weights of each size of the minus 4 mesh portion retained on each sieve shall be determined and recorded. Use a scale or balance conforming to the requirements specified in paragraph 3.1.

**6.3.5** The individual portions shall be saved until the entire minus 4.75 mm (4 mesh) portion of the sample that was washed has been screened, weighed, and the weights recorded, before any of the material is discarded.

**7 Sieving Procedure:**

**7.1** Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Section 7.3.

**7.2** Limit the quantity of material on a given sieve so that all particles have an opportunity to reach sieve openings a number of times during the sieving operation. The following table shows the maximum weight that can be retained on each individual sieve at the completion of the sieving operation. In no case shall the weight be so great as to cause permanent deformation of the sieve cloth.

**7.3** Continue sieving for a sufficient period and in such manner that, after completion, not more than 0.5 percent by weight of the total sample passes any sieve during 1 min. of continuous hand sieving. Perform as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the 4.75 mm (No. 4) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203 mm (8 in.) diameter sieves to verify the sufficiency of sieving.

**7.4** The efficiency of the mechanical shaker shall be checked periodically by comparing results with the hand method. This practice will help determine the length of time required for the mechanical shaker to adequately separate material sizes.

**8 Calculations:**

**8.1** *Plus 4.75 mm (4 Mesh) Material* - For each of the various sieves, the individual weights retained must be converted to total weight passing. The total weight passing is divided by the total weight of the sample multiplied by 100, which will result in the percent passing. (See the example on the following worksheets).)

**8.2** *Minus 4.75 mm (4 Mesh) Material* - Calculating the percentages of the minus 4.75 mm (4 mesh) portion of the sample is simplified by using a reciprocal. The reciprocal is determined by dividing the percent of material passing the minus 4.75 mm (4 mesh) sieve by the weight of the minus

**8 Calculations:** (continued)

4.75 mm (4 mesh) sample before washing. This reciprocal, when multiplied by the various total weights passing, results in the percent passing, in relation to the total sample. (See the example on the following worksheets).

**9 Report:**

**9.1** The results of the sieve analysis shall be reported as the total percentages passing each sieve size and reported to the nearest whole number for all material coarser than the 75 $\mu$m (200 mesh). The 75 $\mu$m (200 mesh) material shall be reported to one tenth of one percent. Percentages shall be calculated on the basis of the total weight of the sample, including any material finer than the 75 $\mu$m (200 mesh) sieve.

**10 Hot Plant Mix Aggregates:**

**10.1** Plant mix aggregates shall be governed by the provisions of MT-202, except that sampling will be in accordance with MT-201, which provides that the samples be obtained by means of an approved sampling device.

MBA Form No. 123
3255-1300
(Rev. 3-92)

**Montana Department of Transportation**
***Materials Bureau***
2701 Prospect Ave.
Helena, MT 59620-9726

District Lab. No._____
Lab. No._____ Sample_____ Hole_____ Project_____
Termini_____
Date Sampled_____ Date Received_____ Kind of Deposit_____
Sampled by_____ Title_____ Address_____
Submitted by _____ Title_____ Date_____
Quantity_____ Area by Stationing_____
Area is in_____ Sec._____ T-_____ R-_____
Lab. No._____ County
Owner_____ Address_____
Sta. and/or Tons Production Sample_____ Lift No. _____
Examined for 3/4" CTS A Gr. 2

Wt. of Sample Taken 11.84 Kg. 100.00 % LL_____ PL_____ PI_____
Wt. Retained 4-Mesh 6.40 Kg. 54.05 % Wear_____% Fld. Agg. Chart No._____
Wt. Passing 4-Mesh 5.44 Kg. 45.95 % Fracture_____% Sp. Gr. (F)_____ (C)_____
Before Wash 478.7 After 450.7 LBW 28.0 Max. Dens._____ Soil Class_____
Opt. Moist_____ Wt./Ft.$^3$_____
Dust Ratio_____ Sand Equiv._____

| Cum.wt. | Size | Wt.Pass. | Pct. | Spec. |
|---|---|---|---|---|
| | 114 mm | | | |
| | 100 mm | | | |
| | 90 mm | | | |
| | 75 mm | | | |
| | 63 mm | | | |
| | 50 mm | | | |
| | 37.5mm | | | |
| | 31.5mm | | | |
| | 25 mm | 11.84 | 100 | |
| 1.22 | 16,19mm | 10.62 | 90 | |
| 3.55 | 12.5 mm | 8.29 | 70 | |
| 5.05 | 9.5 mm | 6.79 | 57 | |
| 6.40 | 4.75mm | 5.44 | 46 | |
| 149.5 | 2.36/2.0mm | 329.2 | 32 | |
| 319.1 | .425 mm | 159.6 | 15 | |
| 417.1 | .180 mm | 61.6 | 6 | |
| 450.7 | .075 mm | 28.0 | 2.7 | |

VOLUME SWELL Specimen

| Age | Treat. | % Swell | Spec.Condition |
|---|---|---|---|
| | | | |

ADHESION

| % Adhesion | Bitumen | Adhesive Agent |
|---|---|---|
| | | |

CHECKED AND APPROVED Name _____
Date _____

REMARKS: PLUS 4.75 mm (4 MESH) MATERIAL - The total weight passing each sieve divided by the total weight of the sample (11.84 Kg.), multiplied by 100, results in percent passing.
EXAMPLE: 5.44 ÷ 11.84 = 0.46 X 100 = 46%

MINUS 4.75 mm (4 MESH) MATERIAL - (By reciprocal method) A reciprocal is determined by dividing the percent of material passing the 4 mesh (45.95) by the weight of the minus 4 mesh sample before washing (478.7 grams). This reciprocal (0.0960) multiplied by the various total weights passing, results in the percent passing in relation to the total sample.

FHWA 104 (Rev. 11/87)
3[illegible]-1150
MT270

# DEPARTMENT OF TRANSPORTATION
# FIELD AGGREGATE CHART

Project No. **(Sample for Clinging Fines)** Designation_____ Mat'ls. Supvr._____
County_____ Laboratory Pit No._____ Test For_____
Pit Location_____ Section_____ Township_____ Range _____

| | | |
|---|---|---|
| Test No._____ Lot No._____ | Test No._____ Lot No._____ | Test No._____ Lot No._____ |
| Date_____ | Date_____ | Date_____ |
| Sampled By_____ | Sampled By_____ | Sampled By_____ |
| Tested By_____ | Tested By_____ | Tested By_____ |
| Stationing_____ | Stationing_____ | Stationing_____ |
| Lift_____ Lane_____ | Lift_____ Lane_____ | Lift_____ Lane_____ |
| Wt.of Sample Taken 25.23 lbs. 100 % | Wt.of Orig. Sample Taken 25.23 lbs. | Wt.of Sample Taken_____ lbs. 100% |
| Wt.Retained 4-Mesh 11.59 lbs. 45.9 % | Difference in Weight | Wt.Retained 4-Mesh_____ lbs._____% |
| Wt.Passing 4-Mesh 13.64 lbs. 54.1 % | Passing 4-Mesh 0.39 lbs. 1.55% | Wt. Passing 4-Mesh_____ lbs._____% |
| Bef.Wash 520.5 Aft.Wash 448.0 LBW 72.5 | Bef.Wash 176.9 Aft.Wash____ LBW_____ | Bef.Wash____ Aft.Wash_____LBW_____ |

| Cum.Wt. | Size | Tot.Wt. Pass. | % | Cum.Wt. | Size | Tot.Wt. Pass. | % | Act.Grading % Passing | Size | % Clinging Fines |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4½" | | | | 4½" | | | | 4½" | |
| | 4" | | | | 4" | | | | 4" | |
| | 3½" | | | | 3½" | | | | 3½" | |
| | 3" | | | | 3" | | | | 3" | |
| | 2½" | | | | 2½" | | | | 2½" | |
| | 2" | | | | 2" | | | | 2" | |
| | 1½" | | | | 1½ " | | | | 1½" | |
| | 1¼" | | | | 1¼ " | | | | 1¼" | |
| | 1" | | | | 1" | | | | 1" | |
| 0 | 3/4" | 25.23 | 100 | 0 | 3/4" | 25.23 | 100 | 100 | 3/4" | 0 |
| 1.29 lbs. | 1/2" | 23.94 | 94.89 | 1.22 lbs. | 1/2" | 24.01 | 95.16 | 95.16 | 1/2" | .27 |
| 4.69 lbs. | 3/8" | 20.54 | 81.41 | 4.43 lbs. | 3/8" | 20.80 | 82.44 | 82.44 | 3/8" | 1.03 |
| 11.59 lbs. | 4 M | 13.64 | 54.06 | 11.20 lbs. | 4 M | 14.03 | 55.61 | 55.61 | 4 M | 1.55 |
| * 219.7 g | 8/10 M | 300.8 | 31.24 | 19.9 g | 8/10 M | 157.0 | 1.38 | 32.62 | 8/10 M | |
| 375.8 g | 40 M | 144.7 | 15.03 | 48.4 g | 40 M | 128.5 | 1.13 | 16.16 | 40 M | |
| 420.5 g | 80 M | 100.0 | 10.39 | 90.0 g | 80 M | 86.9 | 0.76 | 11.15 | 80 M | |
| 447.9 g | 200 M | 72.6 | 7.54 | 174.9 g | 200 M | 2.0 | 0.02 | 7.56 | 200 M | |
| | Total | | | | Total | | | | Total | |

*-4 Mesh Sample Split and Sieved

| | | |
|---|---|---|
| -4+10_____% | -4+10_____% | Note: Report the Percent Clinging Fines as 1.6% |
| Dust Ratio_____% | Dust Ratio_____% | -4+10_____% |
| Moisture_____% | Moisture_____% | Dust Ratio_____% |
| Fracture_____% | Fracture_____% | Moisture_____% |
| Liquid Limit_____ | Liquid Limit_____ | Fracture_____% |
| Plasticity Index_____ | Plasticity Index_____ | Liquid Limit_____ |
| | | Plasticity Index_____ |

Checked By_____ Date_____ Entered By_____ Date_____